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CHANGES IN THE METABOLIC PROCESSES OF LEUKOCYTES DURING THE ACTION OF SHF AND OF INFRARED RADIATION OF LOW INTENSITY

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CHANGES IN THE METABOLIC PROCESSES OF LEUKOCYTES DURING THE ACTION OF SHF AND OF INFRARED RADIATION OF LOW INTENSITY

(I. V. Zakharov)

[Izmeneniye metabolicheskikh protesessov v leykotsitakh pri vozdeystvii na cheloveka SVCh i infrakrasnogo izlucheniya slaboy intensivnosti]

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CHANGES IN THE METABOLIC PROCESSES OF LEUKOCYTES DURING THE ACTION OF SHF AND OF INFRARED RADIATION OF LOW INTENSITY

I. V. Zakharov

(Presented by academician D. A. Markov, from the Academy of Sciences of the Belorussian SSR)

The topic of the effect of radiowaves at the cellular level is insufficiently dealt with in the extensive literature on the biological effects of SHF (super-high frequency) electromagnetic fields. There are but a few studies on this subject [1-5]. In view of this fact as well as of the fact that the reactions of the organism, which occur at the cellular level in response to general irradiation of the body with a SHF field, can be regarded as a sensitive indicator of the field's action, this study deals with investigation of the functional state of human leukocytes during a single general irradiation of volunteers with SHF, low-intensity radiowaves in the centimeter and decimeter ranges. In order to uncover the peculiarities of the biological action of SHF fields, a comparative study was also conducted on the effect of infrared rays on the human body.

Conditions of irradiation effect and method for determination of the functional state of leukocytes. Generators of 3- and 60-centimeter waves were used for SHF irradiation. The density of the power flux (DPF) was determined by means of a PO-1 instrument; it varied between 1 and 5 $\mu W/cm^2$ in the working areas. A filament lamp of 250W was the source of infrared radiation.

A part of the energy of the filament lamp (about 12%) is spent on visible radiation, while the rest is released in the form of infrared rays with a wavelength of 1-3μ and a peak of radiation at 1.1μ. The infrared radiation in the 1-1.4μ range penetrates freely through clothing and through the upper layer of

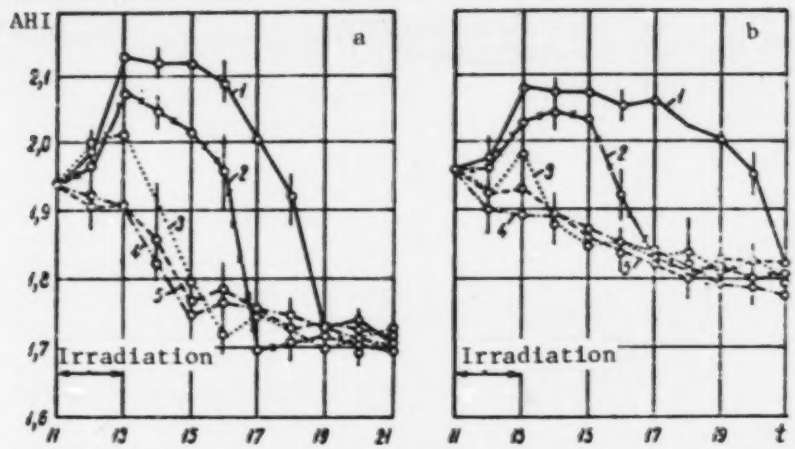
the human skin [6,7]. The source of infrared radiation was placed in such a manner that a DPF of 10-15 and 4,000μW/cm^2 was created in the working areas [8]. The time of irradiation with SHF waves and infrared waves was 2 hours.

Prior to and after irradiation, the number of leukocytes, differential count, pulse rate and temperature of the skin on the forehead were determined. Histochemical tests for peroxidase activity and glycogen content in the leukocytes were performed every hour in the course of 10 hours, starting with the time of irradiation. The functional state of the leukocytes was determined by the change in the activity of peroxidase by the method of Lele, while the glycogen content was determined according to Mac-Manus [9]. A hundred leykocytes were counted in every smear. Then the average histochemical index (AHI) of peroxidase activity and glycogen content was calculated using the formula of Astaldi and Verg [10].

At the same time with studies on the groups of people irradiated with SHF waves and infrared rays, similar studies were conducted on control groups; identical working and living conditions were created for the latter as for the groups under investigation (except for irradiation with electromagnetic fields).

Comparative time-dependent changes in the functional state of the leukocytes during irradiation with 3- and 60-centimeter SHF waves and infrared rays. Studies on the functional state of the leukocytes in the course of time were conducted in four series of experiments: 1) 2 hours of irradiation with SHF waves of 3-centimeter length, continuous irradiation; 2) 2 hours of irradiation with 60-centimeter SHF waves, continuous irradiation; 3) 2 hours of irradiation with infrared rays, DPF in the range of 4,000μW/cm^2; 4) 2 hours of irradiation with infrared rays, DPF about 10-15μW/cm^2.

In the first 3 series of experiments, blood preparations were subjected to identical irradiation at the same time with the irradiation of humans; these were prepared by the hanging drop method on polystyrene slides. The results of the first two series of experiments showed that a single overall irradiation with 3- and 60-centimeter SHF waves causes an increase in the activity of peroxidase and in the glycogen contents of leukocytes (see figure). The results were statistically significant ($P < 0.001$) [11].



Changes in the activity of peroxidase (a) and in the glycogen content (b) of leukocytes in the peripheral blood following a single general irradiation of humans with SHF waves and low intensity infrared rays:

1 — 3-centimeter waves; 2 — 60-centimeter waves; 3 — IR rays with an intensity of 4,000μW/cm^2; 4 — IR rays with an intensity of 10-15 μW/cm^2; 5 — control; t — time in days; AHI — average histochemical index in arbitrary units.

In the period of after-effect of the SHF irradiation, the increased content of peroxidase was maintained for 5 hours (in the case of the 3-centimeter waves) and 3 hours (in the case of the 60-centimeter waves), while the increased glycogen content was maintained for 7 and 3 hours, respectively. In the fourth series of experiments (IR rays with DPF 10-15μW/cm^2), no changes were detected in the level of peroxidase activity and in the glycogen content of the leukocytes. However, when the intensity of irradiation of humans with IR rays was increased (series 3, DPF 4,000μW/cm^2), changes were noted in the functional state of the leukocytes which were similar to the changes occurring after SHF irradiation. It should be noted that the activity of peroxidase and the glycogen contents of the leukocytes increased in this case only in the

period of irradiation; they were identical to the control as soon as one hour after cessation of the irradiation.

Irradiation of blood preparations with SHF waves and infrared rays caused no changes in the parameters under investigation. No changes were recorded in the number of leukocytes and in the differential count in any of the experimental series, while the pulse rate and skin temperature increased only in the 3rd series of experiments (IR rays, DPF 4,000μW/cm^2).

Discussion of the experimental results. Comparison of the leukocyte reactions occurring in response to the irradiation of humans with SHF waves and infrared rays shows that low-intensity SHF irradiation (DPF 1-5μW/cm^2) causes definite metabolic changes; a slightly higher irradiation with infrared rays, which was however comparable in its energy level (DPF 10-15μW/cm^2), caused no such effect. It takes a considerable increase in the energy level of the flux of infrared radiation (4,000μW/cm^2) which leads to changes in pulse rate and to overall heating of the body, to cause changes in the metabolic processes of the leukocytes. However, these changes which correspond in their trend to the changes occurring after irradiation with the SHF field, appear only in the period of irradiation of humans with infrared rays and disappear upon its cessation. Contrarily, the peroxidase activity and the glycogen content of the leukocytes remain high for some time after cessation of the irradiation with SHF waves.

Definite differences can be assumed to exist in the nature of the biological effect between SHF and infrared rays on the basis of functional changes in the state of the leukocytes which occur during irradiation of humans with SHF waves and are absent during irradiation with low-intensity infrared rays. Apparently, the explanation for the difference between the effect of SHF waves and of low-intensity infrared rays consists in the nonthermic effect which is inherent to the SHF field; this is due to the phenomena of polarization in the cytoplasm of receptor cells; no such effect characterizes the infrared rays [12-14]. The appearance of similar reactions during irradiation with SHF waves of low intensity (1-5μW/cm^2) and with infrared rays at an intensity which causes heating of the body (4,000μW/cm^2) points to the nonspecific nature of the organism's reactions to irradiation with SHF fields. The reaction of leu-

kocytes to irradiation with SHF waves has a functional character and is one manifestation of the general nonspecific adaptive reaction of the organism [15]. This appears from the fact that as early as several hours after cessation of irradiation, the peroxidase activity and glycogen content do not differ from the control values. It should be noted that a variety of physiological parameters (leukocyte count and differential count, pulse rate and skin temperature) did not change after irradiation with low-intensity SHF waves. Therefore, the reaction of the organism at the cellular level can be envisaged as a highly sensitive parameter of the effect of SHF waves.

Comparison of the results of irradiation of humans and of blood preparations shows that the changes in the functional state of the leukocytes appear only when the whole body is irradiated. This fact leads to the assumption that an important role in the leukocyte reaction to irradiation with SHF waves is played by the coordinating systems of the organism (for example, the nervous and humoral systems). This assumption is supported by the fact that while 3-centimeter waves penetrate less deeper in the body than decimeter waves (3-centimeter waves — 0.189 cm; 60-centimeter waves — 3.2 cm) [12], the effect of centimeter waves is more marked.

It may be assumed that the effects observed by us are due to the action of SHF waves on the receptor system in the skin and thus are based on a neuroreflex mechanism of action.

I wish to express my profound gratitude to Ye. T. Kulin, candidate of biological sciences, for discussion of the results of this study and to academician P. F. Rokitskiy, of the Academy of Sciences of Belorussian SSR, for his help in the statistical analysis of the experimental data.

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